U. S. DEPARTMENT OF COMMERCE
DANIEL C. ROPER, Secretary
NATIONAL BUREAU OF STANDARDS
LYMAN J. BRIGGS, Director

INTERCHANGEABLE GROUND-GLASS JOINTS, STOPCOCKS, AND STOPPERS

(THIRD EDITION)

COMMERCIAL STANDARD CS21–36

[Supersedes CS21–34]

Effective Date, May 15, 1936

A RECORDED STANDARD OF THE INDUSTRY

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PROMULGATION

of

COMMERCIAL STANDARD CS21–36

for

INTERCHANGEABLE GROUND-GLASS JOINTS, STOPCOCKS, AND STOPPERS

(Third Edition)

On December 19, 1929 a joint conference of representative manufacturers, distributors, and users of laboratory glassware adopted a commercial standard for interchangeable ground-glass joints, which was subsequently accepted by the industry and promulgated as Commercial Standard CS21–30. Following the success of this standard, the standing committee recommended its extension to include interchangeable ground-glass stopcocks and stoppers, and a suitable revision was accepted and approved by the industry for promulgation as Commercial Standard CS21–34. Increasing use of interchangeable joints developed a demand for additional sizes and lengths; the standing committee accordingly recommended a second revision, as shown herein, which the industry accepted and approved for promulgation by the United States Department of Commerce, through the National Bureau of Standards.

The standard is effective for new production beginning May 15, 1936.

Promulgation recommended.

I. J. Fairchild,
Chief, Division of Trade Standards.

Promulgated.

Lyman J. Briggs,
Director, National Bureau of Standards.

Promulgation approved.

Daniel C. Roper,
Secretary of Commerce.

INTERCHANGEABLE GROUND-GLASS JOINTS, STOPCOCKS AND STOPPERS

(Third Edition)

COMMERCIAL STANDARD CS21–36

PURPOSE

1. The purpose of this commercial standard is to provide standard dimensional requirements for obtaining, within practical limits, interchangeability in ground-glass joints, stopcocks, and stoppers for ordinary laboratory and industrial work. It covers dimensional interchangeability only and does not involve physical or chemical characteristics of glass.

SCOPE

2. This standard covers (1) interchangeable ground-glass joints from 5 to 71 mm approximate diameter at the large end of ground zone for full-length grindings and from 5 to 40 mm for medium length grindings, for laboratory and industrial glassware; (2) interchangeable straight-bore, ground-glass stopcocks from 1 to 10 mm bore; (3) interchangeable ground-glass stoppers from 9 to 38 mm approximate diameter at the large end of ground zone for volumetric flasks, stoppered erlenmeyer flasks, stoppered cylinders, separatory funnels, and iodine determination flasks; and (4) interchangeable ground-glass stoppers from 14 to 45 mm approximate diameter at the large end of ground zone for reagent bottles.

GENERAL REQUIREMENTS

3. *Taper.*—All commercial standard interchangeable ground-glass joints, stopcocks, and stoppers shall have a taper of 1 mm ± 0.006 mm per centimeter of length on diameter (1 to 10).

4. *Master gages.*—All commercial standard interchangeable ground-glass joints, stopcocks, and stoppers shall be made from working tools that have been checked with standard gages certified by the National Bureau of Standards. A set of standard master gages is maintained at the above Bureau for reference.

5. *Master gage material and taper.*—All master gages shall be made of tool steel, hardened and ground. Taper shall be 1 mm ± 0.0006 mm per centimeter of length on diameter.

DETAIL REQUIREMENTS

A. INTERCHANGEABLE GROUND-GLASS JOINTS

TABLE 1.—*Standard dimensions for full-length interchangeable ground-glass joints* [1]

Standard joint size number (designation)	Approximate diameter at small end A	Approximate length of ground zone B	Computed diameter at large end of ground zone (gaging point) C
	mm	mm	mm
5/20	3	20	5
7/25	5	25	7.5
10/30	7	30	10
12/30	9	30	12
14/35	11	35	14.5
19/38	15	38	18.8
24/40	20	40	24
29/42	25	42	29.2
34/45	30	45	34.5
40/50	35	50	40
45/50	40	50	45
55/50	50	50	55
60/50	55	50	60
71/60	65	60	71

[1] While table 1 contains all of the joints covered by CS21–34, together with the two new sizes, 40/50 and 60/50, the size designations have been changed from the diameter at the small end of the ground zone to the approximate diameter at the large end, and include a length designation to provide for indication of different lengths. This change in the system of designation was made at the suggestion of the Deutsche Gesellschaft für Chemisches Apparatewesen E. V. as a step toward international uniformity. Users of apparatus with interchangeable ground-glass joints numbered according to CS21–34 may order replacement parts by specifying the size number etched on the apparatus; the absence of a length designation will inform the manufacturer or distributor that the number refers to the old series. If the size given includes the length designation it will be clear that the number belongs to the new series. Medium-length joints covered by table 2 have diameters at the large end of the ground zone equal to the large diameter of the corresponding full-length joint in table 1.

TABLE 2.—*Standard dimensions for medium-length interchangeable ground-glass joints*

Standard joint size number (designation)	Approximate diameter at small end A	Approximate length of ground zone B	Computed diameter at large end of ground zone (gaging point) C
	mm	mm	mm
5/12	3.8	12	5.0
7/15	6.0	15	7.5
10/18	8.2	18	10.0
12/18	10.2	18	12.0
14/20	12.5	20	14.5
19/22	16.6	22	18.8
24/25	21.5	25	24.0
29/26	26.6	26	29.2
34/28	31.7	28	34.5
40/35	36.5	35	40.0

6. *Tube diameter and length.*—The outside diameter of the tube shall correspond approximately to the outside diameter of the small end of the inner member of the ground joint, dimension A, table 1. Total assembled length, including tubing, of joints shown in tables 1 and 2 shall be approximately 30.5 cm (12 in).

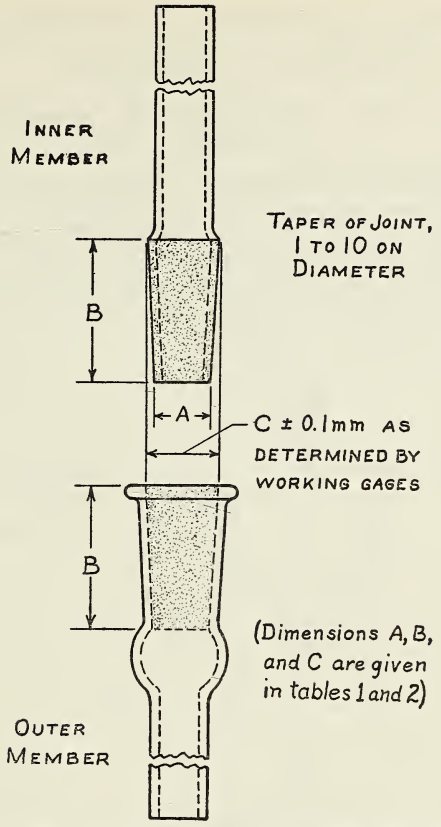


FIGURE 1.—*Interchangeable Ground-Glass Joint.*

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS JOINTS

7. *Plug gage.*—The length of the taper portion of plug gage shall be the approximate length of the ground zone as given in table 1 plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ± 0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

8. *Ring gage.*—Length of ring shall equal approximate length of ground zone as given in table 1 within ± 0.1 mm. Outside diameter of ring shall be approximately twice the diameter at small end of ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

9. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ± 0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and taper shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

10. *Fit of product in working gages.*—The product (both inner and outer members) shall fit in the corresponding working gages within ±1.0 mm along the axis from the gaging point.

B. INTERCHANGEABLE STRAIGHT-BORE GROUND-GLASS STOPCOCKS

11. Interchangeable ground-glass stopcocks are not intended for vacuum apparatus or for use with light liquids. When it becomes necessary to replace a plug of an interchangeable stopcock which, by constant abrasion, has become worn so that the shell is enlarged while the plug is diminished in size or otherwise physically or chemically acted upon, then interchangeable stopcock plugs cannot be expected to fit properly in the shell.

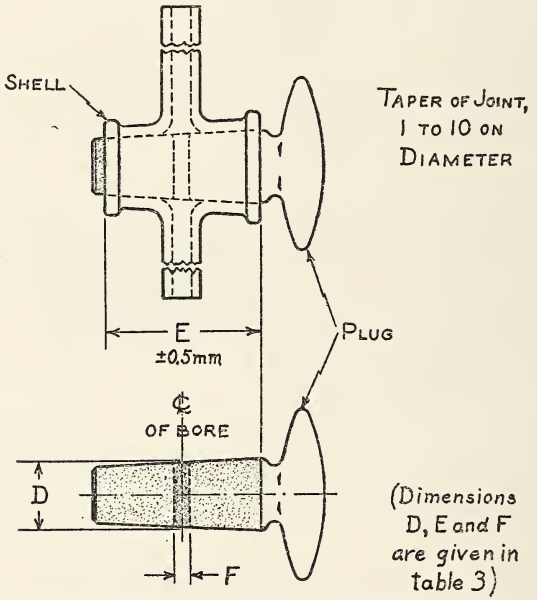


FIGURE 2.—*Interchangeable ground-glass stopcock.*

TABLE 3.—*Standard dimensions for interchangeable straight-bore ground-glass stopcocks*

Standard stopcock number	Diameter of plug at center line of bore D	Length of shell ± 0.5 mm E	Diameter of bore hole in plug F
	mm	mm	mm
1	12	30	1
1½	12	30	1½
2	12	30	2
3	17	40	3
4	17	40	4
5	20	44	5
6	20	44	6
8	25	52	8
10	35	56	10

12. *Shell.*—The length of shell (product) shall be as given in table 3, ±0.5 mm.

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS STOPCOCKS

13. *Plug gage.*—The length of taper portion of the master plug gage shall be the length of the shell as given in table 3 plus not less than 12 mm nor more than 14 mm. Plug shall have a circumferential reference line (gaging point) approximately 0.1 mm (0.075 to 0.150 mm) wide located on new gages at a point one-half the length of the shell plus 10 to 11.5 mm from the large end of the taper portion. The diameter at center of reference line (gaging point) shall equal diameter of plug at center line of bore, table 3, within ±0.003 mm. Plug shall have two short axial lines 180° (±0.5°) apart intersecting reference line (gaging point) for checking location of bore hole. Plug gage shall also have two circumferential reference lines near the large end, located at points (½ E − 0.5 mm) and (½ E + 0.5 mm), respectively, from the gaging point. The tolerance on location of these lines shall be plus or minus 0.05 mm. The small and large ends of the taper portion of the gage shall be ground perpendicular to the axis, and each plug gage shall be provided with a suitable handle.

14. *Ring gage.*—The length of the master ring gage shall equal the length of the shell, table 3, plus 0.2 mm, minus 0.0 mm. Ring gage shall have a central milled recess or window. Width of recess measured parallel with the axis shall be approximately one-fourth the length of the shell, and the width of the opening at the inner surface of ring, measured perpendicular to axis, shall not exceed one-fourth the length of the shell. Reference line in recess shall be approximately 0.1 mm (0.75 to 0.150 mm) wide and placed midway between ends of ring gage within ±0.1 mm on new gages.

15. The outside diameter of rings shall be approximately twice the diameter at center line of bore, table 3, but not less than 25 mm. The ends of the ring gage shall be ground perpendicular to the axis.

16. *Fit of mating gages.*—When a master ring is fitted hand-tight on its mating plug, the middle of the reference lines of each member shall not be apart more than 0.15 mm. The finish of the ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with the surface of the plug covered with a light coating of prussian blue in oil. Full contact shall be shown at the reference line (gaging point) under these conditions.

17. *Fit of product in working gages.*—The product (inner member) shall fit in the ring gage so that the bore of the plug shall center on the reference line of the ring gage as near as can be judged by the eye. The shell shall fit on the plug gage so that reference line (gaging point) is ½ E ± 0.5 mm from the large end of the shell. At the center line of bore, the grinding of both plug and shell shall show full contact with the respective gages, and shall be free from any striations. The small end of ground zone of stopcock plug shall extend beyond end of ring gage not less than 2 mm.

C. INTERCHANGEABLE GROUND-GLASS FLASK STOPPERS

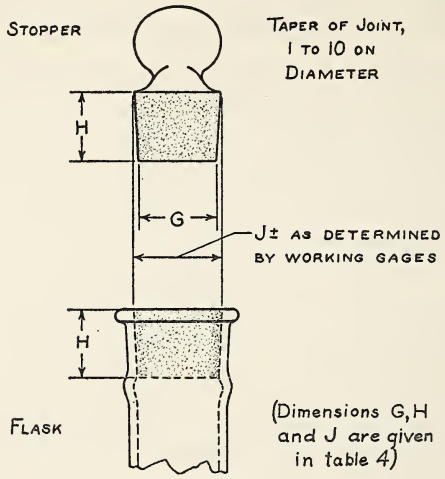


FIGURE 3.—*Interchangeable ground-glass flask stopper.*

TABLE 4.—*Standard dimensions for interchangeable ground-glass flask stoppers* [1]

Standard flask stopper number	Approximate diameter at small end G	Length of ground zone H	Computed diameter at large end of ground zone (gaging point) J
	mm	mm	mm
9	8	14 ± 1	9.4
13	12	14 ± 1	13.4
16	15	15 ± 1	16.5
19	18	17 ± 1	19.7
22	20	20.5 ± 1.5	22.05
27	25	21.5 ± 1.5	27.15
32	30	21.5 ± 1.5	32.15
38	35	30 ± 2	38.0

[1] The sizes of interchangeable ground-glass stoppers shown in table 4 are identical with those covered by CS21–34; only the designations have been changed from the diameter at the small end of ground zone to the diameter at the large end, to conform with joint designations of tables 1 and 2. Danger of ambiguity has been avoided by the selection of numbers, none of which are duplicates of those shown in CS21–34.

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS FLASK STOPPERS

18. *Plug gage.*—The length of the taper portion of plug gage shall be the maximum length of the ground zone as given in table 4, plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ±0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

19. *Ring gage.*—Length of ring shall equal maximum length of ground zone as given in table 4 within ±0.1 mm. Outside diameter of ring shall be approximately twice the diameter at the small end of the ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

20. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ±0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

21. *Fit of product in working gages.*—The large end of stopper shall come flush with large end of ring gage within ±0.5 mm along the axis for stoppers nos. 9 to 19, inclusive; and within ±1.0 mm along the axis for stoppers nos. 22 to 38, inclusive.

22. Plug gage shall enter flask so that gaging point on plug shall be at least 0.5 mm and not over 1.5 mm above extreme top surface of flask for stoppers nos. 9 to 19, inclusive; and at least 1.0 mm and not over 3.0 mm for stoppers nos. 22 to 38, inclusive.

D. INTERCHANGEABLE GROUND-GLASS REAGENT BOTTLE STOPPERS

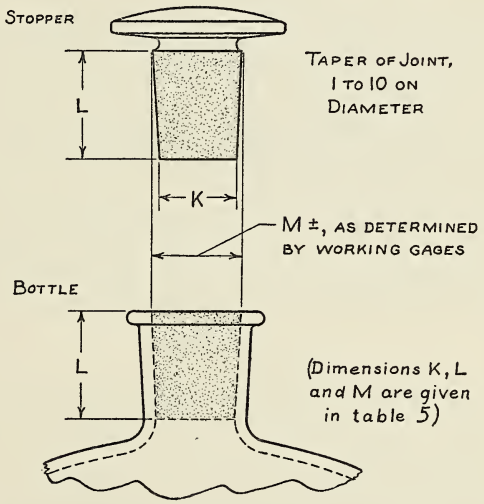


FIGURE 4.—*Interchangeable ground-glass reagent bottle stopper.*

TABLE 5.—*Standard dimensions for interchangeable ground-glass reagent bottle stoppers* [1]

Standard bottle stopper number	Approximate diameter at small end K	Length of ground zone L	Computed diameter at large end (gaging point) M
	mm	mm	mm
14	12.5	20 ± 1.5	14.5
19	16.6	22 ± 1.5	18.8
24	21	30 ± 2	24.0
29	25.5	35 ± 2	29.0
34	30.5	40 ± 2	34.5
45	40.3	47 ± 2	45.0

[1] The sizes of interchangeable ground-glass stoppers shown in table 5 are identical with those covered by CS21–34; only the designations have been changed from the diameter at the small end of ground zone to the diameter at the large end to conform with joint designations of tables 1 and 2. Danger of ambiguity has been avoided by the selection of numbers, none of which are duplicates of those shown in CS21–34.

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS REAGENT BOTTLE STOPPERS

23. *Plug gage.*—The length of the taper portion of plug gage shall be the maximum length of the ground zone as given in table 5, plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ±0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

24. *Ring gage.*—Length of ring shall equal maximum length of ground zone as given in table 5 within ±0.1 mm. Outside diameter of ring shall be approximately twice the diameter at the small end of the ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

25. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ±0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

26. *Fit of product in working gages.*—The large end of stopper shall come flush with large end of ring gage within ±0.5 mm along the axis for stoppers nos. 14 and 19 and within ±1.0 mm along the axis for stoppers nos. 24 to 45, inclusive.

27. Plug gage shall enter bottle so that gaging point on plug shall be at least 0.5 mm and not over 1.5 mm above extreme top surface of bottle for stoppers nos. 14 and 19; and at least 1.0 mm and not over 3.0 mm for stoppers nos. 24 to 45, inclusive.

MARKING

28. Interchangeable ground-glass joints, stopcocks, and stoppers conforming to this commercial standard shall be marked on both members with this symbol——→  indicating standard taper, followed by the size designation and the trade mark of manufacturer or distributor.

29. Joints and stoppers covered by tables 1, 2, 4, and 5 are shown diagrammatically in figure 5, pages 10 and 11, grouped for ready comparison.

EFFECTIVE DATE

The standard became effective for new production May 15, 1936.

STANDING COMMITTEE

The following comprise the membership of the standing committee, which is to review, prior to circulation for acceptance, proposed revisions to keep the standard abreast of progress. Comment concerning

the standard and suggestions for revision may be addressed to any member of the committee or to the Division of Trade Standards, National Bureau of Standards, which acts as secretary for the committee.

J. Edward Patterson (chairman), Arthur H. Thomas Co., 230 S. Seventh St., Philadelphia, Pa.
W. D. Collins, American Chemical Society, c/o U. S. Geological Survey, Washington, D. C.
Prof. Edward H. Cox, Swarthmore College, Swarthmore, Pa.
Walter R. Eimer, Eimer & Amend, 3rd Ave. and 18th St., New York, N. Y.
William Geyer, Scientific Glass Apparatus, Co., 49 Ackerman St., Bloomfield, N. J.
Herman K. Kimble, Kimble Glass Co., Vineland, N. J.
Frederick Kraissl, Corning Glass Works, 501 Fifth Ave., New York, N. Y.
Edw. A. Krebs, Eck & Krebs, 131 W. 24th St., New York, N. Y.
D. R. Miller, National Bureau of Standards, Washington, D. C.
Leonardo Testa, Fixed Nitrogen Testing Laboratory, U. S. Dept. of Agriculture, Friendship Postoffice, Washington, D. C.
W. J. D. Walker, Corning Glass Works, Corning, N. Y.

HISTORY OF PROJECT

Pursuant to a request from manufacturers and distributors of laboratory glassware, a general conference of manufacturers, distributors, and users of interchangeable ground-glass joints was held on December 17, 1929, at the National Bureau of Standards, Washington, D. C., to consider the establishment of commercial standard tapers and diameters on the basis of a preliminary draft submitted by a committee of manufacturers and dealers. The conference adopted the proposed standard unanimously, after making certain minor adjustments, and recommended it for acceptance by the industry. After acceptance had been formally given, the standard was promulgated and issued in printed form as Commercial Standard CS21–30, which became effective August 1, 1930.

FIRST REVISION

The standing committee, as a result of conferences on May 25 and July 20, 1933, recommended the extension of the commercial standard to include 3, 9, and 65 mm sizes of interchangeable ground-glass joints; 5 sizes of interchangeable straight-bore, ground-glass stopcocks; 8 sizes of interchangeable ground-glass flask stoppers; and 6 sizes of interchangeable ground-glass reagent bottle stoppers. The proposed revision was circulated to the industry on January 5, 1934, for written acceptance, with the result that the revised standard was accepted and authorized by the industry for publication as Commercial Standard CS21–34.

SECOND REVISION

In response to a demand for additional sizes and lengths of grindings, the standing committee met on February 11, 1936, and adopted a second revision, which was circulated to the industry for acceptance on March 18, 1936.

APPENDIX

The success of Commercial Standard CS21–30 led the standing committee to recommend an extension of the principle of interchangeability to other items and later to other sizes of joints. From the point of view of the National Bureau of Standards, such added items should be considered as more or less on trial and subject to such future changes as may be warranted by composite experience.

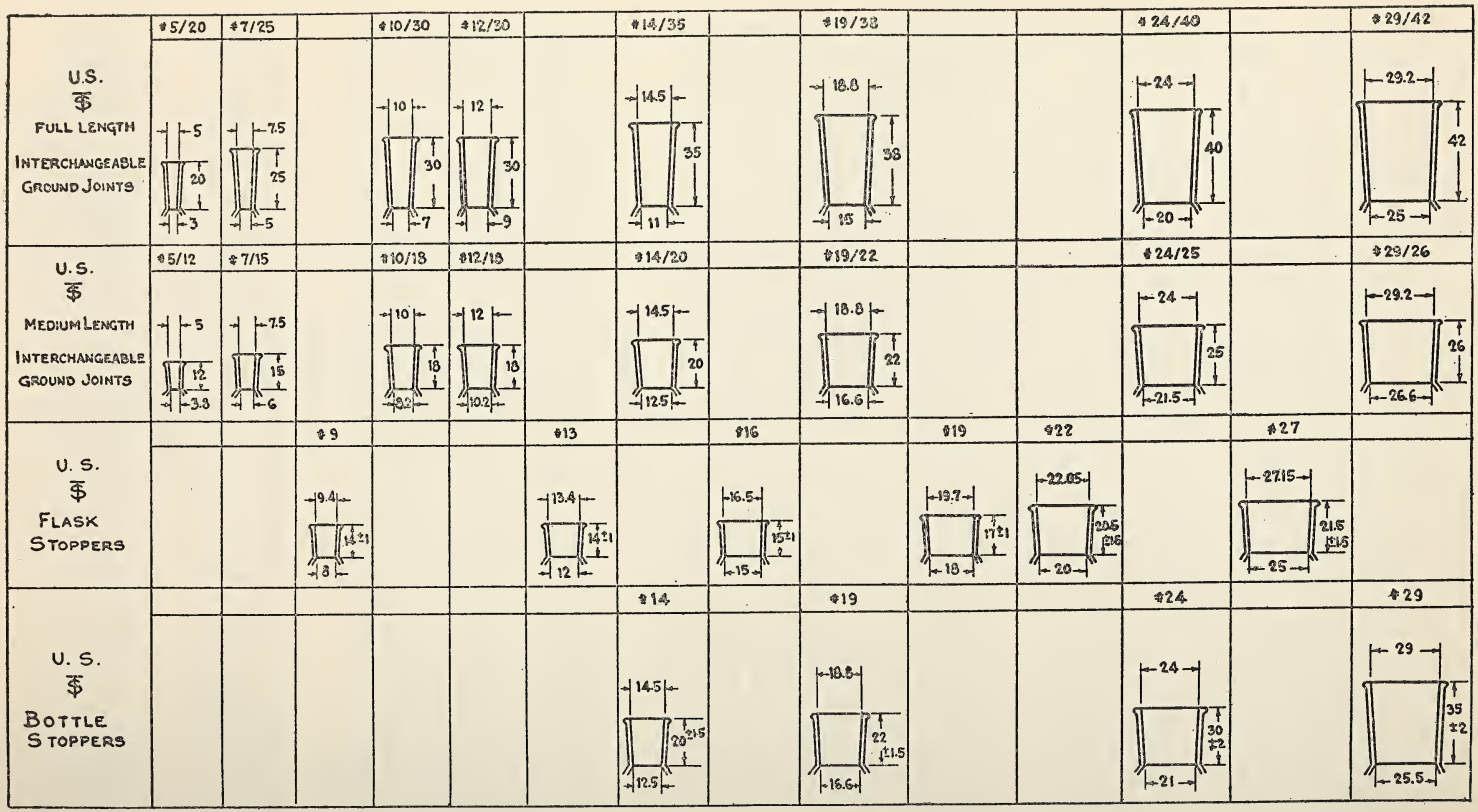
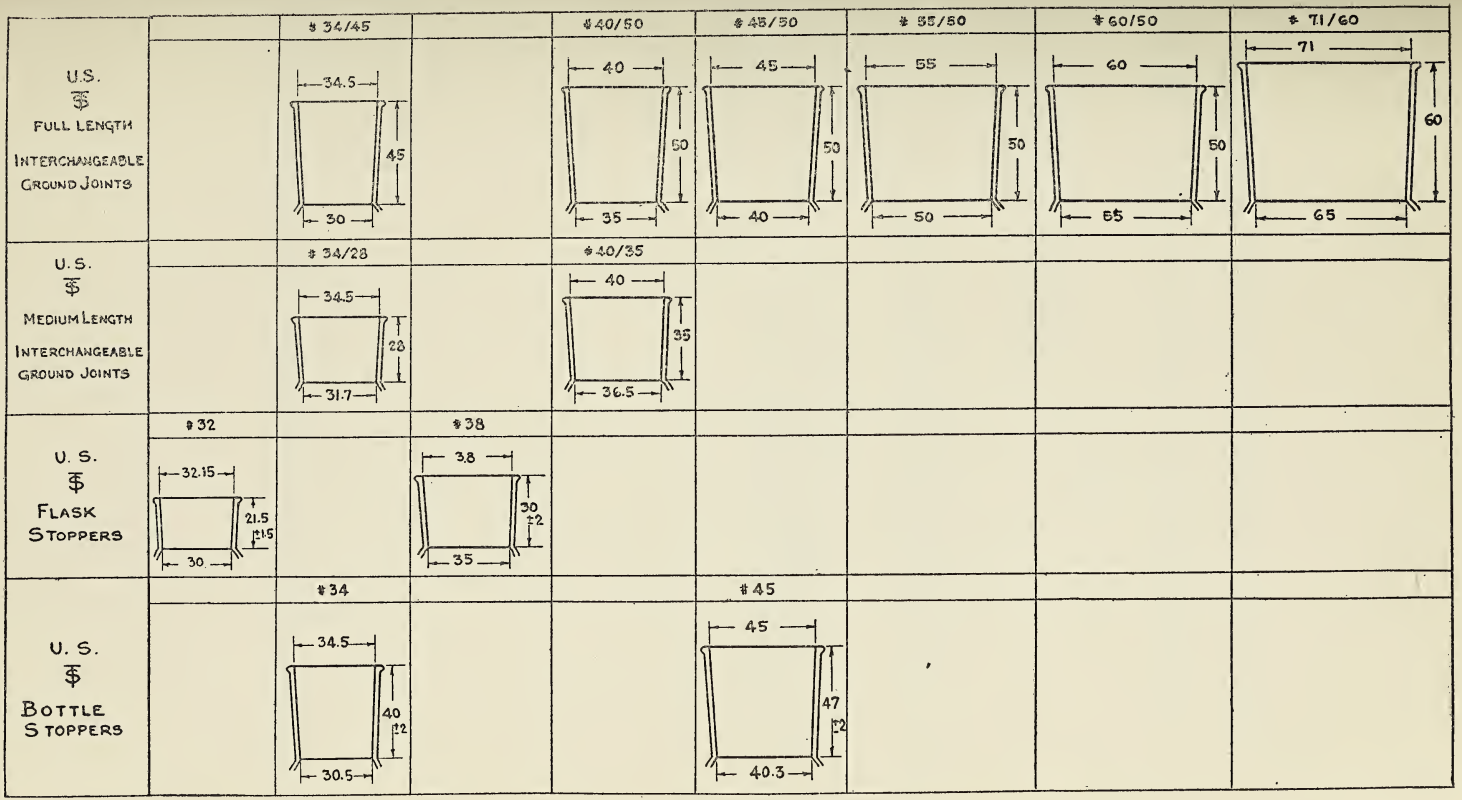


FIGURE 5.—*Comparative sizes of interchangeable joints and stoppers.*
(Dimensions given are in millimeters.)



(FIGURE 5.—Continued.)

ACCEPTANCE OF COMMERCIAL STANDARD

This sheet properly filled in, signed, and returned will provide for the recording of your organization as an acceptor of this commercial standard.

Date_____

Division of Trade Standards,
National Bureau of Standards,
Washington, D. C.

Gentlemen:

Having considered the statements on the reverse side of this sheet, we accept the Commercial Standard CS21–36 as our standard of practice in the

Production [1] Distribution [1] Use [1]

of interchangeable ground-glass joints, stopcocks, and stoppers.

We will assist in securing its general recognition and use, and will cooperate with the standing committee to effect revisions of the standard when necessary.

Signature_____

(Kindly typewrite or print the following lines)

Title_____

Company_____

Street address_____

City and State_____

[1] Please designate which group you represent by drawing lines through the other two. In the case of related interests, trade papers, etc., desiring to record their general approval, the words "in principle" should be added after the signature.

(Cut on this line)

TO THE ACCEPTOR

The following statements answer the usual questions arising in connection with the acceptance and its significance:

1. *Enforcement.*—Commercial standards are commodity specifications voluntarily established by mutual consent of the industry. They present a common basis of understanding between the producer, distributor, and consumer and should not be confused with any plan of governmental regulation or control. The United States Department of Commerce has no regulatory power in the enforcement of their provisions, but since they represent the will of the industry as a whole, their provisions through usage soon become established as trade customs, and are made effective through incorporation into sales contracts by means of labels, invoices, and the like.

2. *The acceptor's responsibility.*—The purpose of commercial standards is to establish for specific commodities nationally recognized grades or consumer criteria, and the benefits therefrom will be measurable in direct proportion to their general recognition and actual use. Instances will occur when it may be necessary to deviate from the standard and the signing of an acceptance does not preclude such departures; however, such signature indicates an intention to follow the commercial standard where practicable, in the production, distribution, or consumption of the article in question.

3. *The Department's responsibility.*—The major function performed by the Department of Commerce in the voluntary establishment of commercial standards on a Nation-wide basis is fourfold: First, to act as an unbiased coordinator to bring all branches of the industry together for the mutually satisfactory adjustment of trade standards; second, to supply such assistance and advice as past experience with similar programs may suggest; third, to canvass and record the extent of acceptance and adherence to the standard on the part of producers, distributors, and users; and fourth, after acceptance, to publish and promulgate the standard for the information and guidance of buyers and sellers of the commodity.

4. *Announcement and promulgation.*—When the standard has been endorsed by companies representing a satisfactory majority of production, the success of the project is announced. If, however, in the opinion of the standing committee of the industry or the Department of Commerce, the support of any standard is inadequate, the right is reserved to withhold promulgation and publication.

ACCEPTORS

Individuals and organizations listed below have indicated, in writing, acceptance of this specification as their standard of practice in production, distribution, or use, but such endorsement does not signify that they may not find it necessary to deviate from the standard, nor does it signify that the producers so listed guarantee all of their products to conform with the requirements of this standard.

ASSOCIATIONS

American Gas Association, Cleveland, Ohio.
American Glassware Association, New York, N. Y. (In principle.)
American Medical Association, Chicago, Ill. (In principle.)
American Pharmaceutical Association, Washington, D. C.
Scientific Apparatus Makers of America, Chicago, Ill.

FIRMS

Abbott Laboratories, North Chicago, Ill.
Ace Glass, Inc., Vineland, N. J.
Advance Solvents and Chemical Corporation, New York, N. Y.
Agfa Ansco Corporation, Binghamton, N. Y.
Akron, University of, Akron, Ohio.
Alabama Polytechnic Institute, School of Chemistry and Pharmacy, Auburn, Ala.
Alaska, University of, College, Alaska.
Albany Laboratories, Inc., Albany, N. Y.
Alfred University, Alfred, N. Y.
American Chemical Paint Co., Ambler, Pa.
American Cyanamid and Chemical Corporation, Azusa, Calif.
American Distilling Co., The, Philadelphia, Pa.
American Instrument Co., Silver Spring, Md.
American Research Glassware Co., Inc., Philadelphia, Pa.
Analytical Laboratories, The, Jersey City, N. J.
Arizona State Teachers College, Flagstaff, Ariz.
Arizona, The University of, Tucson, Ariz.
Associated Clinics and Hospitals, Inc., Minneapolis, Minn.
Associated Electric Laboratories, Inc.' Chicago, Ill.
Atkin & McRae, Los Angeles, Calif.
Atlas Powder Co., Experimental Laboratory, Tamaqua, Pa.
Baker University, Baldwin, Kans.
Barium Products, Ltd., San Francisco, Calif.
Barrett Co., The, Research Laboratory, Edgewater, N. J.
Barrow-Agee Laboratories, Inc., Memphis, Tenn.
Bay Chemical Co., Inc., Weeks, La.
Berge, J. & H., New York, N. Y.
Binney & Smith Co., New York, N. Y.
Biscayne Chemical Laboratories, Inc., Miami, Fla.
Blair Laboratory, The, Newark, N. J.
Block Laboratories, Chicago, Ill.
Bohn & Kern Co., Zanesville, Ohio.
Boston University, Department of Chemistry, Boston, Mass.
Bowser-Morner Testing Laboratories, Dayton, Ohio.
Bradley Polytechnic Institute, Peoria, Ill.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Calif.
Brewer & Gardner, Philadelphia, Pa.
Brown & Sharpe Manufacturing Co., Providence, R. I.
Bucknell University, Lewisburg, Pa.
Buffalo Apparatus Corporation, Buffalo, N. Y.
Burnham Plumbing Co., Inc., San Francisco, Calif.
Burrell Technical Supply Co., Pittsburgh, Pa.
Butler University, Indianapolis, Ind.
Calco Chemical Co., Inc., Bound Brook, N. J.
California Institute of Technology, Pasadena, Calif.
California, University of, Berkeley, Calif.
Calkins Co., The, Los Angeles, Calif
Cameron, Geo. W., El Paso, Tex.

Carbide and Carbon Chemicals Corporation, South Charleston, W. Va.
Carnegie Institute of Technology, Pittsburgh, Pa.
Case School of Applied Science, Cleveland, Ohio.
Central Scientific Co., Chicago, Ill.
Charlotte Chemical Laboratories, Inc., Charlotte, N. C.
Chemical Manufacturing Corporation, Norfolk, Va.
Chicago Apparatus Co., Chicago, Ill.
Chittick, James, New York, N. Y.
Church & Dwight Co., Inc., Syracuse, N. Y.
Clarkson College of Technology, Potsdam, N. Y.
Clinical Laboratory, The, Newark, N. J.
Colby College, Waterville, Maine.
Coleman & Co., W. B., Philadelphia, Pa. (In principle.)
Colgate University, Hamilton, N. Y.
College of City of New York, Department of Chemistry, New York, N. Y.
College of the Pacific, Stockton, Calif.
Colorado School of Mines, Golden, Colo.
Colorado State College, Fort Collins, Colo.
Colorado, University of, Boulder, Colo.
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